CHAPTER 3. CROPS

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GENERAL

Most of the irrigated cropland in South Carolina is planted to corn, cotton, and soybeans. Irrigation is of greatest economic importance, however, on specialty or high value crops including vegetables, strawberries, blueberries, tobacco, nurseries, and orchards.

For full benefits from irrigation, other inputs should be supplied in ample amounts. Special attention should be given to proper fertilization; selection of adapted varieties that are capable of producing high yields; control of weeds; insects, and diseases; and use of cultural practices such as row spacing and increased plant population.

Deep soils with low available soil water moisture during periods of peak crop water moisture use commonly show the greatest response to irrigation. Information on the suitability of soils for different crops and for irrigation is provided in the SCS Technical Guides.

Erosion and wetness problems commonly are intensified by irrigation. Consequently, consideration of the physiographic features of the soils is critical to selection of a satisfactory system of irrigation. Conservation tillage, buffer strips of perennial vegetation, vegetated terraces and diversions, contour farming, and grassed waterways are effective erosion control practices which are compatible with most systems of irrigation. Conservation tillage and windbreaks provide effective control of soil blowing. However, attention should be given to height and location of windbreaks so as not to create a barrier to irrigation equipment and cause excessive shading of crops. See Table 2-5 for the major benefits and limitations of soil conservation practices. To drain wet soils, use of subsurface drainage with surface inlets and grassed waterways should be maximized to avoid creating barriers to irrigation.

ROOTING DEPTH AND MOISTURE EXTRACTION

The rooting depth of the crop determines the size of the soil moisture reservoir (soil water control zone) to be managed. The rooting depth depends on the crop being grown and soil conditions. Table 3-1 gives the recommended soil water control zone of common crops grown in most soils in South Carolina. However, examination of crop rooting depths should always be made to determine the proper depths for water management in a particular system. Soils with shallow depths to bedrock, gravel, hardpans, high water tables and other restrictions to root development limit the rooting depth of crops. On these soils, the potential for increased yields and profitability with irrigation is limited by the shallow rooting depth. Because of the limited soil moisture reservoir, these soils require frequent irrigation. The rooting depths on soils with hardpans and on soils with high water tables can be increased by subsoiling and drainage respectively. If the water table is very high over most of the season, a water table management system should be considered since the irrigation requirements would be reduced due to the availability of stored water.

In uniform soils with ample available moisture, plants use water rapidly from the upper part of the root zone and slowly from the lower part. Most plants have similar moisture extraction patterns. The usual extraction pattern for soils with a uniform texture is as follows: about 40 percent from the upper quarter of the root zone, 30 percent from the second quarter of the root zone, 20 percent from the third quarter, and 10 percent from the bottom quarter (see figure 1). Thus, if 50 percent of the total root zone available moisture has been used, the upper portion will be at less than 50 percent available moisture, and the lower portion will be at greater than 50 percent available moisture.

Frequent shallow irrigations will maintain a high moisture level (i.e., low soil moisture tension) in the upper portion of the root zone. If, however, irrigations are scheduled too frequently, excessive evaporation will occur, excessively shallow root zone will result, or, in the extreme, water application depths may be too small to effectively penetrate the crop root zone. With heavy irrigations, losses through runoff, nutrient leeching out of root zone, and risks of overwetting are increased. Thus, a planned method of scheduling irrigation is essential for effective use of irrigation (see Irrigation Water Management Chapter 11 in this Guide for more information on scheduling irrigations).

IRRIGATION AND CROP PRODUCTION

For maximum production and the most efficient use of water, plants must have ample moisture throughout the growing season. For most crops there are critical periods in the growing season when a high moisture level must be maintained for high yields. Except for germination and transplanting, the critical periods are periods of peak moisture use. The peak moisture use period can best be defined as that time when soil moisture stress can most reduce yield in an otherwise healthy crop. This is not the only time in the life of the crop that moisture stress reduces yield, but it is the time when moisture stress has the greatest effect.

If there is enough moisture for germination and for the development of an adequate stand, the critical moisture period is almost always in the latter part of the growing season during the reproductive growth stage. Although plants indicate moisture stress by various symptons, yields will usually be reduced by the time the plants show stress. Time of irrigation should be determined by an examination of the soil moisture content. Maintaining soil moisture levels in the moisture control zone at or above the 60% level (40% management allowed deficit) as noted in Chapters 2 and 11 will normally provide adequate water for high yields. For sandy soils this corresponds generally to maintaining soil water tension below the 35 to 40 centibar range in the middle of the surface layer. For most sandy clay soils in South Carolina, the corresponding tension is in the range of 60 to 80 centibars or greater. Critical moisture periods and specific information for various crops are shown in Table 3-2 at the end of this chapter.

With most crops, maximum yields are attained by maintaining a high soil moisture level along with other needed inputs throughout the growing season. However, more profit may be realized by limiting irrigations to the particular crop's critical moisture use periods in some situations.

Many South Carolina farms have limited water supplies for irrigation. Farmers relying on surface stored water (in ponds) may run short of water during extended dry periods. Selection of crops showing the most response to irrigation and timing irrigation treatments to meet critical water needs of the crop is essential.

Table 3-1. Recommended Soil-Water Control Zone for Selected Mature Crops

Crop	Depth of Soil-Water Control Zone Inches
Corn...........................	18-24
Cotton.........................	18-24
Cucumbers......................	9
Peaches........................	18
Peanuts........................	18
Pecans.........................	18-24
Southern Peas..................	12
Soybeans.......................	18-24
Tomatoes	12
Tobacco	18
Sorghum	18
Watermelon	12
Pasture	24
Alfalfa	24
Blue Berries	12
Strawberries	9
Small Vegetable	9

Note: Depths given are for soils without restrictive layers and for soils with restrictive layers which have been loosened by subsoiling. Use lesser depth as applicable for soils with restrictive layers that limit deep root development. Where two values are given, the depths shown are for Piedmont and Coastal Plains soils respectively.

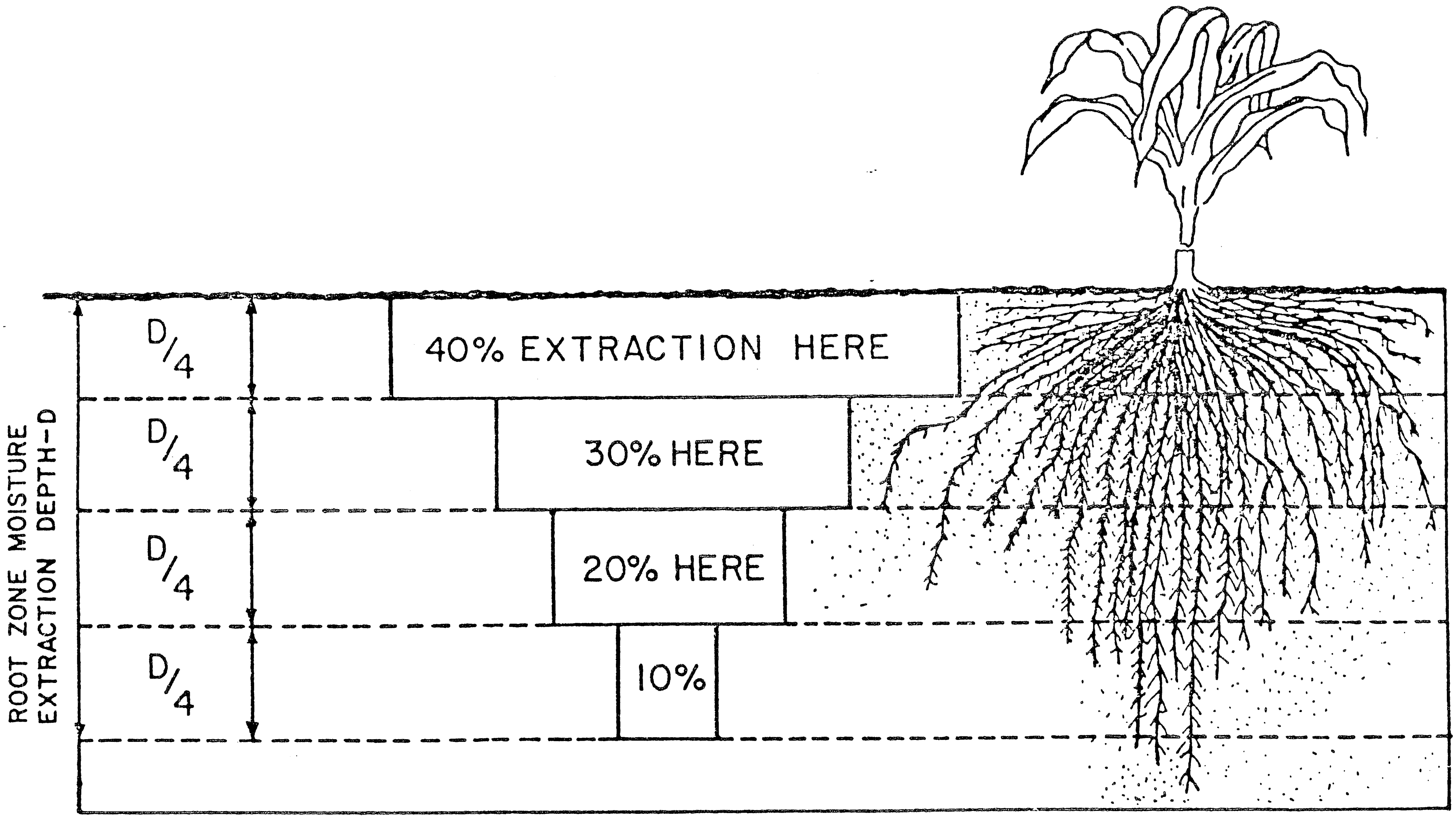

FIGURE 1 AVERAGE MOISTURE-EXTRACTION PATTERN OF PLANTS GROWING IN A SOIL WITHOUT RESTRICTIVE LAYERS AND WITH AN ADEQUATE SUPPLY OF AVAILABLE MOISTURE THROUGHOUT THE ROOT ZONE.

IRRIGATION NEEDS OF SPECIFIC CROPS

ALFALFA

Alfalfa uses a lot of water for high production. However, Clemson University agronomists have found that the length of life of alfalfa is reduced by irrigation without greatly increasing yields. Consequently, irrigation commonly is not recommended. If alfalfa is to be irrigated, the normal procedure is to irrigate 3 to 5 days after each cutting. However, irrigation should also be considered in the early spring before cutting and in the fall. These are critical periods of growth. Thus, irrigation at these times will aid in maintenance of a highly productive stand.

BLUEBERRIES

The root system of a blueberry plant begins to grow before the top. If the winter has been dry, irrigation should begin 3 to 4 weeks before the top starts to grow. From bloom until harvest is a critical moisture period for blueberries. After harvest, the blueberry continues to make new growth to support next season's crop. Water and adequate fertility are critical during this stage of growth.

CORN

Corn is shallow rooted until it nears tasseling. Consequently, the effective soil moisture reservoir before tasseling is not as deep as from tasseling to maturity. Demand for water from 60 days to maturity is high, and is especially high and important during the tasseling and grain filling period. During this period, maintaining soil moisture below the 0.25 - 0.4 tension range in medium to coarse textured soils will normally provide adequate water for high yields. While moisture use is high and moisture supply is most critical during this period, moisture stress during any time from germination through maturity can significantly reduce yields. Thus, irrigation schedules should allow for irrigation throughout the life of the corn as needed.

COTTON

Cotton has significant drought tolerance; however, timely irrigation may increase yields considerably. The critical moisture period is from first bloom through boll maturing. High moisture levels after the boll forming stage will delay the crop, increase the amount of immature fibers, and can cause boll rots. High moisture levels early in the season can cause seedling blight and damping off.

GRAPES

The year of planting is a critical moisture period for grapes. After the first year, critical moisture period is during sizing of the fruit.

PEACHES

The fruit growth pattern of peaches is referred to as a double sigmoid growth curve. There is an initial period of rather rapid fruit enlargement followed by a pit hardening period during which fruit enlargement is slight. Finally, the flesh of the fruit thickens, and total enlargement is very rapid. During this final swell, moisture stress reduces yields to the greatest extent.

Research findings are not conclusive on the proper available soil moisture to maintain for peaches. But, data on cling peaches shows that the growth rate during final swell is reduced when the soil moisture tension in the lower portion of the soil-water control zone approaches 5 bars.

Excessive wetness contributes to short life. Thus, the soil moisture tension in the soil-water control zone should not be below about 0.10 bar for any appreciable period of time for sprinkler irrigation when the entire root zone is wetted.

Irrigation recommendations for peaches are similar to those for pecans given in a later section in this chapter. Therefore, refer to the pecan section for more information.

PEANUTS

Peanuts respond well to irrigation with the greatest increases in yield coming on sandy textured soils. Commonly, sprinkler irrigation commenced at 50 percent moisture depletion or less during the peak growing season (beginning at about 80 to 100 days of age) will provide adequate water for high yields. Research results ("Peanut Irrigation in Georgia" by L. E. Samples) with use of tensiometers on a loamy sand indicate sprinkler irrigation should commence when the topsoil tensiometer set at the four inch depth reads 25 centibars (approximately 45 percent depletion of AWC as per Figure A-2 of Appendix A) or more. Tensiometers at the 12 and 20 inch depth would typically each read about 45 centibars in relation to the 25 reading at the 4 inch depth.

The profitability of peanut irrigation is particularily dependent on good water management and control of diseases such as white mold which possibly may be enhanced by the presence of continuously high soil water content. If moisture is not adequate at planting, a preplant irrigation is especially beneficial in producing good stands.

PECANS & WALNUTS

Irrigation is very important on newly planted trees. A soil water control zone should be maintained near the tree for a least a year and, in the absence of suitable rainfall, water should be applied throughout the growing season. Critical moisture periods for older trees are during nut forming and nut filling. For walnuts excessive wetness contributes to short life, thus irrigation for mature walnut trees is questionable.

Sprinkler irrigation commencing at the 50 percent AWC level is generally recommended to ensure minimum plant stress. Research by Jeff Daniell in Georgia has shown that about 1.5 net inches of water should be applied at each irrigation on most soils utilized for pecans. (Do not exceed the AWC or the intake capacity of the soil, however.)

Drip irrigation research in South Carolina and Georgia (Jim Aitken and Jeff Daniell respectively) indicate that about 2,400 net gallons of water per day per acre should be supplied to mature pecan trees in 12 hours or less at high moisture stress periods. This volume is applicable to a tree canopy area of about 70 to 75 percent or greater. Areas with significantly less tree canopy (as with a young orchard) should be supplied with proportionally less water. Research by Daniell indicates that excess water in the Southeast may decrease yield and pecan quality.

During high moisture stress periods, pan evaporation normally reaches 0.3 to 0.35 inches per day in the Southeast (extreme values as high as 0.5 inches/day were recorded in the summer drought of 1986). A rule of thumb suggested by Daniell for scheduling drip irrigation using pan evaporation is to vary the application amount in proportion to the pan evaporation approximately as follows:

Average Daily Pan Evaporation During Previous Week (inches)	Application Amount (Gallons/Acre/Day)
.33	2,400
.25	1,800
.15	1,100

When approximately 0.5 or more inches of rainfall occur, Daniell recommends turning off the system for 3 days. The system is not turned off if less than 0.5 inches of rain are received.

A method of scheduling drip irrigation recommended by Jim Aitken is to use tensiometers placed 9 inches from 1 GPH emitters in sandy soils at depths from 12 to 24 inches. Aitken's results for young trees on Lakeland sand indicate maximum tree growth with maximum yield and nut quality were obtained by maintaining soil moisture below 5 centibars at the tensiometer locations as compared to the 14 centibar level.

Operators should provide a check on either of the above methods of scheduling by visually observing the trees to note signs of stress and by using the feel and appearance method of determining soil moisture as given in this Guide. These methods used in combination should provide good water management.

Information given in this section for pecans was obtained primarily from publications noted in Appendix E and from personal communications with the authors. Persons giving planning and/or design assistance for pecan irrigation are encouraged to refer to the noted printed materials and utilize applicable information. Also, verbal communication with the authors is encouraged.

SMALL GRAINS

Commonly, small grains are most responsive to irrigations at the preplant and boot stage. However, moderate to high small grain yields can be obtained in most years without irrigation.

SORGHUM

Grain sorghum is a drought tolerant plant but one that responds well to irrigation. Commonly, the most important irrigation is at preplanting. However, irrigation at the boot to early heading stage can significantly improve yields.

SOYBEANS

Inadequate moisture during germination and early seedling growth can prevent establishment of a uniform stand. However, after establishment of the stand, ARS research has shown little benefit from irrigation until blooming. Soybeans use large amounts of water in the reproductive phase. Particularly during pod growth and seed fill, lack of water will significantly reduce yields. Water stress early in the reproductive stage may result in higher than normal levels of flower abortion, leading to reduced numbers of pods per plant. Moisture deficiencies during the seed filling stage result in smaller than normal seeds.

Research in South Carolina has shown that soybean yields may be enhanced an average of 10 to 15 bushels per acre with irrigation. This assumes good management with non-irrigated yields in the 30-bushel range. For irrigated double-crop soybeans planted behind wheat, yields are predictably five bushels or so below the potential for full season plantings. However, irrigated double-crop yields have consistently been in the 35 to 50-bushel range, depending on the soil and other management factors.

For irrigated full-season soybeans, high-yielding varieties from maturity groups V, VI, and VII are suggested. Varieties with good branching habit and lodging resistance are preferred. When selecting varieties for double cropping under irrigation behind wheat, maturity groups VII and VIII are recommended since they will have more time to develop vegetatively before bloom. Varieties with yield potential and good branching habit and lodging resistance are preferred. Take care to select varieties which have good disease and nematode resistance. Check Extension Circular 545, Soybean Varieties for South Carolina, for details concerning resistance to disease along with suitability for double-cropping and irrigation.

Soybeans should have adequate soil moisture for optimum growth and development through R7 growth stage, which is physiological maturity. This is defined as the stage at which there is one normal pod with mature pod color (e.g. tan) on the main stem. Usually, at least half the leaves have dropped and the remaining leaves are yellow.

In general, other management considerations for irrigated soybeans are not different than for non-irrigated soybeans. Examples are tillage, row spacing, plant population, fertilization, pest management, and harvesting.

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STRAWBERRIES

The strawberry plant is shallow-rooted with 80-90 percent of its roots in the top 12 inches of soil. In the matted row cultural system, moisture is necessary in the surface soil to permit runner plants to set and make maximum growth. Irrigation is needed at transplanting, during fruit bud formation in the fall and fruit enlargement. Irrigation begun at 50 percent of available soil moisture appears to provide adequate moisture for high yields.

Solid set sprinkler irrigation is recommended as a means of providing frost protection for strawberries in South Carolina. See Chapters 5 and 10 of this guide for more information on frost control applications.

TOBACCO

Irrigation of tobacco at transplanting will greatly improve survival and early growth. An analysis of moisture uptake by tobacco has shown the main moisture uptake zone to be the top 6 inches from transplanting to 3 weeks of age, the top 12 inches during the next two weeks, and 18 inches for the remainder of the growing period. Thus, the depth to which the soil is irrigated should be adjusted for the age of the tobacco. Under limited irrigation, the critical time other than at transplanting is from the knee-high stage until the top leaves are filled out. Light irrigation during harvesting may be needed to avoid premature firing, improve body, and reduce wilting.

Tobacco is especially sensitive to overly wet soils. Thus, the soil moisture tension should not be reduced below 8 to 10 centibars for any appreciable period, i.e. 24 hours. Over-irrigation at early growth stages can increase damage by cool temperatures and limit root development.

VEGETABLES

Vegetables are 80-95 percent water. Consequently, their yield and quality suffer rapidly from drought. Moisture shortages early in the crop's development can delay maturity and reduce yields. Moisture shortages later in the growing season commonly reduce quality and yields.

Most vegetables have small seeds which are planted 3/4 inch deep or less. With the rapid drying of the upper layer of soil, these shallow planted seeds can be left with enough moisture to begin germination but not enough to complete germination. Thus, a poor stand results. Sprinkler irrigation of 1/2 to 3/4 inch immediately after planting will settle the soil and provide adequate moisture for germination. Sprinkler irrigation should be applied slowly to avoid crusting of the surface. For larger seeds, irrigation prior to seeding is desired.

A transplanter will not apply adequate water for vegetable transplants in dry soil. A light sprinkler irrigation of 1/2 to 3/4 inch will provide a ready supply of water for the transplants and will help set the transplants firmly in the soil. Fruits such as tomatoes and peppers are injured by large fluctuations in soil moisture. When soil moisture is not maintained at the proper level, fruit cracking results, yields decrease, and diseases are encouraged.

Research results (ASAE Paper No. 82-2518 by Camp, Robbins, & Karlen) indicate tomato yield and fruit size are enhanced when soil water tension at the lower edge of the soil-water control zone (12 inch depth) is maintained in the 5 to 40 centibar range for a silt soil in the South Carolina coastal plain. (The 40 centibar tension corresponds to approximately the 15 percent depletion level of AWC as per Figure A-2 of Appendix A.) Accordingly, optimun tension range for tomatoes on sandy or clayey soils should be slightly lower or higher respectively. It is important to note however that there is no conclusive data to prove there is one best soil moisture level for tomatoes. It is expected that most other vegetables would respond similiarly to the above noted management schedule for tomatoes.

TABLE 3-2 CRITICAL MOISTURE PERIODS OF MAJOR CROPS

CROP	CRITICAL MOISTURE PERIOD
Alfalfa	Start of flowering and immediately after cutting
Blueberries	When fruit and leaf bud is forming and sizing of the berry
Corn	Tasseling through grain filling
Cotton	First bloom through boll maturing
Fruit trees	Fruit development
Grapes	Sizing of the fruit
Sorghum	Boot, bloom, and dough stages
Pasture	After grazing 1/
Peanuts	First bloom through nut forming
Pecans	During nut set (April-May) and nut fill (August-September)
Small grain	Boot, bloom and early head stage
Soybeans	First bloom to seed enlargement
Strawberries	Bud set and fruit enlargement
Tobacco	Knee high to full bloom 2/
Vegetables	
Beans (Dry, lima, pole, snap)	Flowering
Broccoli	Head development 1/

TABLE 3-2 CRITICAL MOISTURE PERIODS OF MAJOR CROPS (CONT'D.)

CROP	CRITICAL MOISTURE PERIOD
Cabbage	Head development
Carrot	Root expansion 1/
Cantalopes	Flowering and fruit development
Celery	Continuous
Collards	Continuous
Cucumber	Flowering and fruiting
Eggplant	Flowering and fruiting
Greens (turnip and mustard)	Continuous
Lettuce (head)	Head expansion 1/
Okra	Flowering
Onion	Bulbing and bulb expansion 1/
Peas, Green	Flowering
Southern	Flowering and pod swelling
Peppers	Transplanting, flowering up to ½ fruit
Potato, Irish	After flowering
Potato, Sweet	First and last 40 days 2/
Pumpkin	Fruiting
Rutabagas	Root expansion
Squash	Fruit sizing
Tomato	Fruit expansion 2/
Turnip	Root expansion
Watermelon	Fruit expansion

1/ Moisture is also critical during seed germination.
2/ Moisture is also critical in the seedling and transplanting stages.